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# Scaffolding citizen inquiry science learning through the nQuire toolkit

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## Abstract

Citizen science is a popular paradigm of research collaboration between scientists and non-professional members of the public with the aim to contribute data to natural and physical science projects such as species identification. We have utilised this paradigm to scaffold online personal inquiry learning within informal settings. The nQuire Missions toolkit is a web platform to host the development and management of personal inquiry missions by young people combined with a sensor-based mobile application to support the collection of data on mobile phones. Scaffolding *citizen inquiry science* is a challenging task, as proposed missions should be personally meaningful, use recognised methods of data collection and analysis, and be valid and ethical. The concept, design and example science missions have been developed through a partnership with Sheffield University Technical College (UTC) where teachers and students acted as design informants. The result of the design exercise has been a specification for the nQuire Missions software and examples of missions which use the mobile phone to collect and share data.

## 1. Research objectives/hypotheses

The research objective of this paper is to present the design and evaluation of web-based and mobile tools that scaffold citizen inquiry science learning and in particular transformative and regulatory inquiry processes in informal settings. Transformative processes refer to core inquiry processes including the generation and testing of hypotheses, data collection and analysis, and reflective argumentation practices. Regulatory processes refer to the management of inquiry such as planning and progress tracking (van Joolingen et al., 2005). Drawing from our previous work on online personal inquiry learning (Anastopoulou et al., 2012), learners might become more engaged with the scientific process if they implement personally meaningful science investigations. Also, to support online personal inquiries, tools should provide functionality, flexibility and support when creating inquiries as well as a repository of exemplar inquiries to facilitate understanding of the inquiry design process (Quintana et al., 2004). Software application (app) projects (Newman et al., 2012) and web 2.0 technologies (Catlin-Groves, 2012) might comprise the means to attract the interest of young people in science. With 81% of UK teens owning a smartphone (eMarketer, 2014) and 85% of US youth using their phones to go online (Duggan & Smith, 2013), merging mobile phone use and citizen inquiry science might hold the potential to raise young people's interest in inquiry learning.

## 2. Methods of data collection

We have partnered with students and staff from Sheffield UTC to design two tools for citizen inquiry science: the nQuire Missions website ([www.nquire-it.org.uk](http://www.nquire-it.org.uk)) and the Sense-it app for Android mobile devices (see Google store). UTC staff proposed the design of a sensor-based mobile application for science inquiries. Sense-it gives access to sensors on phones and tablets, such as their accelerometer, light, sound, humidity sensors and allows users to capture, visualize, store and download log files from the sensors available on their mobile devices. A first prototype of the Sense-it mobile app was developed and a workshop with Sheffield students (Males=86, Females=10, aged 16-18) was implemented to evaluate the app and give students the opportunity to propose personal inquiries using it. Students downloaded the Sense-it app to their devices before the workshop. On the day, they were asked to explore the app's affordances in groups (n=14) and complete two worksheets.

The first one required to evaluate the app by stating what students like/dislike about it and how they would improve it and the second one to write down two inquiries (i.e., title, aim and method of inquiry) that might be implemented using the app. Students' responses were clustered in groups of relevant meaning and reduced into summary categories using thematic analysis (Kvale, 1996). Based on students' suggestions, the design and functionality of the app was improved and some inquiries proposed by students were designed, selected by the researchers on the basis of practicality and broad reach. These inquiries are hosted in the nQuire Missions website which is linked to the Sense-it app and provides support for data visualisation, analysis and interpretation.

### **3. Data analysis/evidence**

The analysis of students' evaluation of the Sense-it app resulted in the following themes: accessibility obstacles including the complex information display (e.g., graphs and sensors were hard to understand), difficulty in navigation, need for simplicity when using the application, lack of attractiveness in colours, sensor icons design and fonts, satisfaction by sensors' customization and the multimodal presentation of recording data (numbers and graphs), and productive use of mobile phones. Students' proposed inquiries were grouped into the following categories: sound, light, acceleration and temperature. Some example inquiries are: What is the top speed of the lifts in the UK?, Does noise affect your concentration in lesson?, How bright does light need to be to wake you up?. Two of these inquiries were designed in the nQuire Missions website; *Find the fastest lift in your area*: Learners are asked to measure the speed of lifts in their area using the Sense-it app, upload their recordings to the website and compare it to other people to identify the fastest lift in their area. *School noise map*: This mission requires from school students to measure the level of noise in different places at their school using the Sense-it app and identify whether noise makes them feel stressed and annoyed. The aim of this mission is to make students aware of the effects of noise and propose measures to minimize it for better well-being.

### **4. Research Outcomes**

The nQuire toolkit can support young people in inquiry sense-making and process management (Quintana et al., 2004). Visual conceptual organizers are used to represent the basic operations of science inquiry including, naming and describing the science mission, numbering its objectives, providing step-by-step guidelines on how to take part in the mission, and selecting the methods of data collection from a repertoire of available instruments such as the Sense-it app. Exemplar inquiry missions (see previous section) assist with the investigation of the underlying properties of inquiry structure. Post-processing algorithms and automatic chart creation scaffold the process of data analysis and interpretation. To support reflective processes and argumentation (Quintana et al., 2004), it provides links to popular social network sites (Facebook, Twitter) to invite 'friends' to join missions, an asynchronous chat channel to enable communication and discussion moderation by experts. The Sense-it app was designed to give access to phone sensors and support transformative inquiry processes (Joolingen et al., 2005) through data collection and visualization. To facilitate participation, the list of sensors required for each mission can be downloaded from the website and a graph on how data recordings relates to other people can be previewed.

## 5. Scientific or scholarly significance of the study or work and limitations

This work is significant for it embeds inquiry learning into citizen science projects to encourage youth civic participation, it facilitates the design of online personal inquiries by offering the nQuire toolkit, and it attempts to bring science closer to the life of young people through the use of their mobile devices. The proposed missions have not yet been evaluated with young people to assess whether they are engaging, raise and sustain interest in science and what their learning outcomes are. This limitation will be addressed within the next months through the design of a workshop with Sheffield students and analysis of data logs.

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